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Methods of Sun-Drying Fruits

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METHODS OF SUN-DRYING FRUITS[1]

P. F. NICHOLS[2]

Fruit-drying is of peculiar importance in California. On the fresh basis the tonnage of fruit dried is four or five times as great as that canned. The principal drying fruits of the world are grown in this state. The concentration of fruits by drying reduces the cost of transportation to the distant markets that are the principal outlets for California fruits. In no state of the Union except California, where the climate is especially favorable, is the sun-drying[3] of fruits practiced on an extensive scale. California produces well over 90 per cent of the dried-fruit output of the United States, only prunes and apples being dried in amounts of commercial significance in other states, where the use of artificial heat is essential for satisfactory drying. Apples are never sun-dried commercially, even in California.

Of the total tonnage of dried fruits produced in the world, dates are the largest item, amounting to from 1,000,000 to 1,500,000 tons. Of this amount, however, only about 10 per cent enters international commerce, and the United States produces only a negligible tonnage. The United States production of dried figs is also relatively small. In the production of other dried fruits the output of California bulks large. According to the California Cooperative Crop Reporting Service, the annual output of dried fruits in California for 1930, 1931, and 1932 averaged over 215,000 tons of prunes, and over 204,000 of raisins. The production of dried apricots and of peaches averages about 20,000 tons each; figs, 12,000 tons; and pears, less than 5,000 tons.

FRUIT FOR DRYING

Fruits are grown and dried in nearly all valley parts of the state. The principal localities, varieties, and seasons, together with the yields, are summarized in table 1. The season, yield, and drying ratio vary, of course, with the variety and locality, as well as from year to year.

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[1] This circular replaces Bulletin 388, now out of print, and in some respects out of date.

[2] Associate in Fruit Products.

[3] The several commercial methods of drying fruits may be defined as follows: *Sun-drying* is drying wholly or for the most part by solar heat. *Evaporation* is drying wholly or for the most part by artificial heat. *Dehydration* is drying by artificial heat while the temperature, humidity, and air flow are controlled by mechanical draft.

TABLE 1

DRIED-FRUIT LOCALITIES, VARIETIES, SEASONS, AND YIELDS IN CALIFORNIA

Fruit	Principal localities	Principal varieties	Drying season	Yield per acre in dried tons	Drying ratio
Apricots	Santa Clara, Ventura, Riverside, Los Angeles, San Benito counties, and Sacramento, San Joaquin and Pajaro valleys	Royal, Blenheim, Tilton, Moorpark	June 15 to August 1	1 to 1½	4:1 to 7:1; Average, 5:1
Figs	San Joaquin and Sacramento valleys	Adriatic, Calimyrna, Black Mission, Kadota	July 20 to November 1	1 to 4; average, Calimyrna, 1 1/5; other varieties, 2½	1½:1; 3½:1 when picked fresh
Peaches	San Joaquin and Sacramento valleys	Muir, Lovell, Elberta	July 15 to September 15	1½	4:1 to 7:1; average, 5:1
Pears	Lake, Sacramento, Solano, Los Angeles, Santa Clara, San Luis Obispo, and Yuba counties	Bartlett	July 15 to October 1	2½ to 5 when all dried; usually only culls dried	4:1 to 7:1; average, 5:1
Prunes	Santa Clara, Sonoma, Napa, and Benito counties; Sacramento and San Joaquin valleys	French, Imperial, Sugar, Robe de Sergeant	August 15 to October 1	Average, 2	2:1 to 3 1; average 2½ to 1
Raisins	San Joaquin and Sacramento valleys	Thompson Seedless, Muscat, Sultana	August 15 to November 1	¾ to 3; average, 1 ton	3:1 to 4:1

Choice of Fruit.—Certain general considerations affect the choice of fruit that is to be dried. As a general rule, sun-drying is a primary industry, some fruits being grown almost or quite exclusively for drying. Hence the fruit used is not low-grade or cull material but orchard or vineyard run. The only important exception to this is pears; in districts other than Lake County the pears dried are usually too large, misshapen, or blemished, and hence separated from fruit picked for cannery or fresh shipment. Some fruits, notably all varieties of apricots, enjoy almost complete interchangeability of use, and may be shipped fresh, canned, and dried equally well, thus seeking the best market. This is true of Bartlett pears except that the demand for dried pears is very limited. Raisin grapes are to some extent shipped fresh, but few are canned. The principal drying varieties of peaches—Muir and Lovell—are used almost exclusively for drying; Elbertas are mostly shipped fresh but some are dried; and the clingstone varieties are used almost exclusively for canning. Figs are dried or shipped fresh, only one variety, the Kadota, being canned. Prunes in California are grown only for drying.

Cultural Practices.—In the production of dried fruits of high quality the first essentials are suitable cultural practices, maturity, and harvesting. Cultural methods are fully discussed in other publications[4] of this station and will not be reviewed here except with respect to one point. Size is an important factor in quality of dried fruits, and of all practices calculated to increase the size of the fruit, thinning seems to be done least effectively. Such an increase in size as to double the market value is often possible, and since the cost of drying a crop increases with the size of the crop it may be far more profitable to produce a small crop of high quality than a large crop of poor quality.

Maturity.—The maturity of the fruit for drying is also of vital importance. In order to produce the best possible dried product the fresh fruit must be of fully developed flavor, well colored, and of maximum sugar content. In short, it should be in proper condition for eating in the fresh state. If at all hard or green it yields a product of poor

[4] Propagation: Stahl, J. L. Propagation of deciduous fruits. California Agr. Exp. Sta. Cir. 294:1-24. 1925.

Pruning: tree fruits: Tufts, Warren P. Pruning bearing deciduous fruit trees. California Agr. Exp. Sta. Bul. 386:1–47. 1925.

Pruning grapes: Bioletti, Frederic T. Vine pruning systems. California Agr. Exp. Sta. Cir. 245:1-4. 1922.

Thinning: Tufts, Warren P. Thinning deciduous fruits. California Agr. Exp. Sta. Cir. 258:1-13. 1923.

Cultural practices are also discussed in general publications which are available for several of the fruits used for drying.

appearance, color, and flavor, with a high shrinkage ratio. These effects are especially apparent in apricots, peaches, and raisins, although they are of importance in all fruits. Pears are picked while hard and only beginning to develop yellow color, and are allowed to ripen after picking. Figs and prunes, on the other hand, are for the most part allowed to drop naturally from the tree. Thompson Seedless grapes should not be picked for drying until the Balling or Brix degree (approximate sugar percentage) of the juice reaches 23°, nor Muscats before 25° is reached.

Harvesting.—As a rule figs and prunes drop to the ground when they are ready for drying. For these fruits the ground should be softened and smoothed before the harvest. The other fruits should be picked by hand in order to secure the best quality. While the harvesting of apricots and peaches can be done at a lower cost per ton by shaking the fruit upon the ground or upon sheets of canvas, the quality always suffers; first, because in falling the fruit becomes bruised or dirty or both, and second, because immature fruit is always mixed with the ripe. Hence shaking should never be practiced for apricots or peaches except in real necessity such as failure to get sufficient pickers, or when the price obtainable for the best fruit will not cover the cost of picking and other costs. Even in such a case the wisdom of shaking is doubtful because of the resulting loss in quality and yield and the necessity of washing, together with the added cost of drying and removing worthless fruit. Where shaking appears necessary, the cheapest and most satisfactory safeguard is to throw away all damaged and especially all even slightly immature apricots and peaches as they are being cut for drying.

In fairness to cutters as well as pickers (who are paid by the box), the boxes should be filled uniformly.

Preparation of Fruit for Drying.—The preparation of the fruit for drying should include the elimination of waste parts as far as possible, and the rejection of pieces that are unacceptable. It should also include any cutting, pitting, lye-dipping, sulfuring, or other treatment necessary to make the fruit dry rapidly and without decomposition or objectionable change in color. While preservation by drying depends upon the reduction of the moisture content so low that bacteria, yeasts, and molds can no longer grow upon and damage the fruit, the reduction of moisture content alone does not always lead to the retention of a sufficiently attractive and stable color. To this end some of the fruits are subjected to the fumes of burning sulfur through which a harmless fruit preservative—sulfurous acid—is introduced. This not only stabil-

izes color and protects the fruit against microorganisms, but also appears essential to the retention of some of the vitamins for which fruits are especially valuable in the diet.

EQUIPMENT FOR DRYING

Much of the equipment required for sun-drying can be and often is used for several different fruits. Except for "natural" (undipped) raisins and some figs, all fruits are brought from the orchard or vineyard to a dry-yard for preparation and drying. There the equipment and operations are concentrated for efficient supervision.

Dry-Yard.—One acre of dry-yard area is required for each 10 to 30 acres of orchard or vineyard; the average is about 1 for 20. The yard should be free from shade and well exposed to prevailing winds and should be level or slope slightly to the south; much slope is to be avoided except in small yards where tracks and cars are not used. It is especially important that the surface of the yard be as free as possible from loose dust, sand, chaff, and any debris that will be scattered on the fruit by the workmen or the wind. With adobe or clay soils an excellent surface may be obtained by smoothing and allowing it to pack hard without any cultivation or irrigation. Another good surface commonly used is obtained by growing hay or grain that is harvested and closely raked just before the drying season, but if this is done the stubble must not be burned. In sandy soils probably the best surface is obtained by growing alfalfa, making a harvesting just before the drying season and not irrigating for some time before. The last two methods make possible some additional returns from the dry-yard.

As a further aid to cleanliness in the dry-yard, any dusty roads or barnyards nearby should be on the side away from the prevailing winds. Where this is not possible the roads should be oiled or sprinkled. Of course, all animals should be kept out of the dry-yard, hence it should be away from the barnyard or should be effectively fenced.

As a matter of comfort and efficiency for those working in the cutting shed, the sulfur houses should be on the side away from the prevailing winds. In the dry-yard there should be the least possible interference or retracing of routes in handling material.

Cars and Tracks.—For all but the smallest yards it is necessary to have some mechanical means of carrying trays. The most common method is to provide a system of tracks for moving cars of trays. Where the surface of the ground is sufficiently smooth a lift-truck or cart with large wheels may be used, but this is apt to increase the spilling of juice

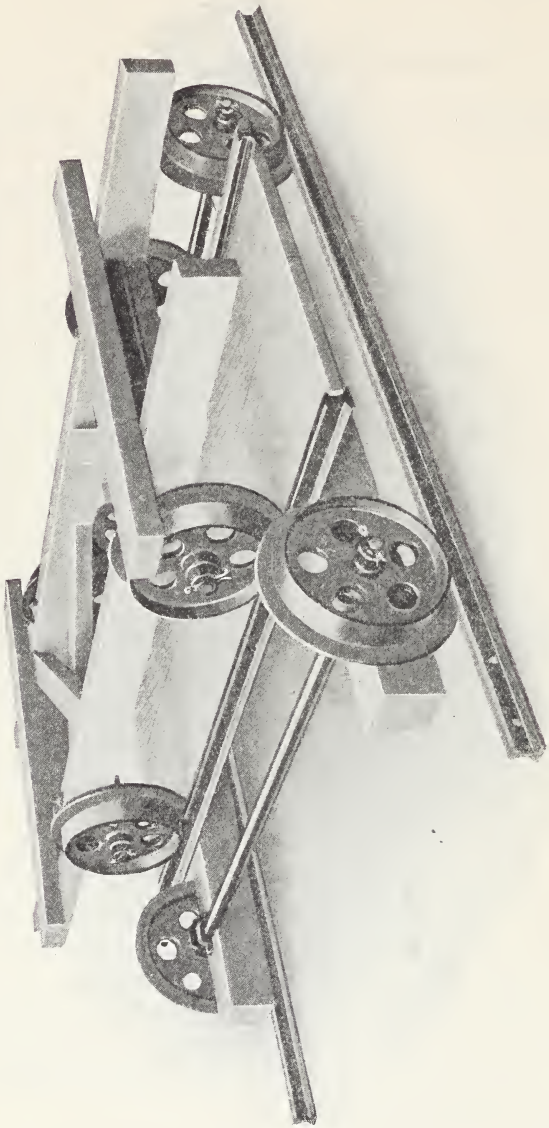


Fig. 1.—Transfer car for moving tray cars to nearby parallel tracks.
(Cut furnished by Anderson Barngrover Co.)

from the cups of cut fruits. A truck or horse and wagon are sometimes used but are generally less economical and sanitary.

Where a track and car system is used, the common cars are of the general type shown on the transfer car in figure 1. Whether the frame is of wood or steel, the car when empty is light enough to be moved by hand from one track to another. Small railroad track weighing 8 to 12 pounds per yard (preferably 10 or 12 pounds) is best, though wooden track faced with strap iron will serve. The ties may be either steel or

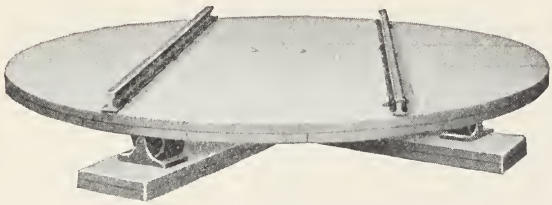


Fig. 2.—Turntable for changing direction of tray cars.
(Cut furnished by Anderson Barngrover Co.)

wooden. The track around the dipper, cutting shed, and sulfur houses should be permanently laid, but the system in the main dry-yard may be portable or permanent.

The layout should permit a circuit for loaded trays going to the dry-yard and empty trays returning to the dipper or cutting shed without reversing direction on the same track. To permit change in direction of loaded cars, either transfer cars (fig. 1) sunk below the main track level, or turntables (fig. 2) are necessary. At the sulfur houses the transfer-truck system is the only satisfactory one, while in the dry-yard proper, turntables have distinct advantages. A point to be borne in mind is that the cars should not be moved more than a very short distance on transfer trucks, because of the extra equipment involved, the

TABLE 2

SOME REQUIREMENTS FOR DRYING APRICOTS, PEACHES, AND PRUNES

Fruit	Acres dry-yard for each 20 acres orchard	Average capacity fresh pounds per day		Number of sulfur houses for each 20 acres orchard	Square feet tray surface per bearing acre
		Pickers*	Cutter		
Apricots	1	1,000	1,000	5	1,150
Peaches	1	2,000	2,000	5	2,000
Prunes	1	1,800	.....	....	2,780

* Apricot orchards picked 2 to 3 times; peaches, 3 times; prunes, 3 or 4 times.

danger of running off the track, and the inconvenience. Wherever transfer cars or turntables are used the tracks must be accurately and rigidly lined up, and a simple, convenient, and sturdy lock without play is an important requirement.

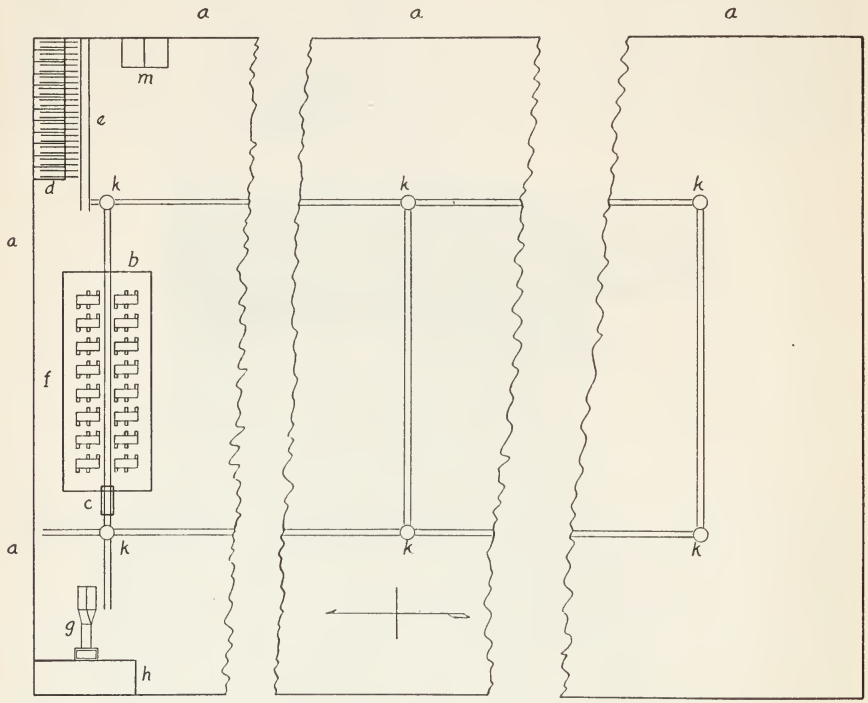
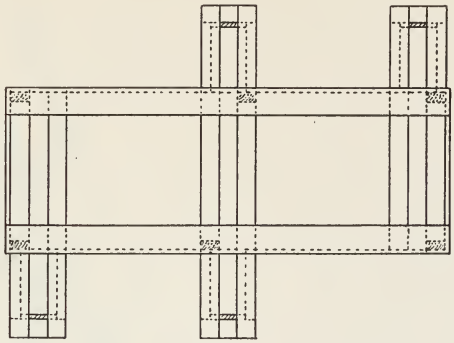


Fig. 3.—Ground plan of a dry-yard of 2½ acres (225 × 485 feet), sufficient for 50 acres of orchard; *a, a,* roads; *b,* cutting shed; *c,* tray washer; *d,* sulfur houses; *e,* transfer track; *f,* space for unloading fresh fruits for cutting; *g,* prune or grape dipper; *h,* unloading platform for prunes or grapes; *k, k,* turntables; *m,* drinking fountain, toilets, and wash bowls. The prevailing wind is assumed to be southwest.

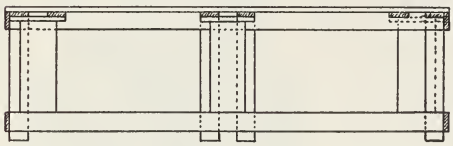
Most of the principles of layout that have been outlined above are exemplified in the dry-yard plan given in figure 3. The sulfur houses and roads are on the sides away from the prevailing winds (assumed to be southwest), transfer tracks are confined to the sulfur houses, and a circuit for cars is provided. The suggested arrangement may not be ideal for all conditions and will naturally require modification to suit the circumstances.

Cutting Shed.—The cutting sheds in use range from permanent buildings with concrete floors to temporary shelters covered with palm thatch or trays. While the latter may serve the purpose after a fashion, the necessity for suitable water supply and toilet facilities in such sheds may be overlooked. Moreover, a permanent roof is a convenience for the winter storage of trays and boxes. On the other hand, good light and

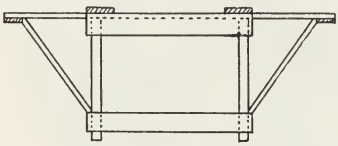
ventilation are necessary. For efficient work also seats and table should be provided for the cutters, and the arrangement should provide for the convenient supply and removal of fruit and trays. As in the dry-yard, all retracing of routes is to be avoided. A suggested arrangement is given in figure 3.



PLAN



SIDE ELEVATION



END ELEVATION

Fig. 4.—Plan of fruit-cutting table, 3 × 8 feet, height 29 inches. This requires 2 pieces 1″ × 6″ × 8′, 4 pieces 1″ × 4″ × 7′10″, 2 pieces 1″ × 4″ × 6′, 4 pieces 1″ × 4″ × 4′6″, 4 pieces 1″ × 4″ × 1′, 4 pieces 1″ × 4″ × 3′, 4 pieces 1″ × 8″ × 2′2″, 6 pieces 2″ × 4″ × 2′3″ (measurements net, to be corrected for any differences in thickness).

The cutting tables should be of convenient height and should be provided with shelves to hold boxes of fruit on each side. Such a table is shown in figure 4. It is very desirable that provision be made, either by pans or slots, for collection of the pits in special containers. Pits and spoiled fruits should not be returned to or collected in boxes used for fruit, because they make the boxes sticky and mar the appearance of the fruit.

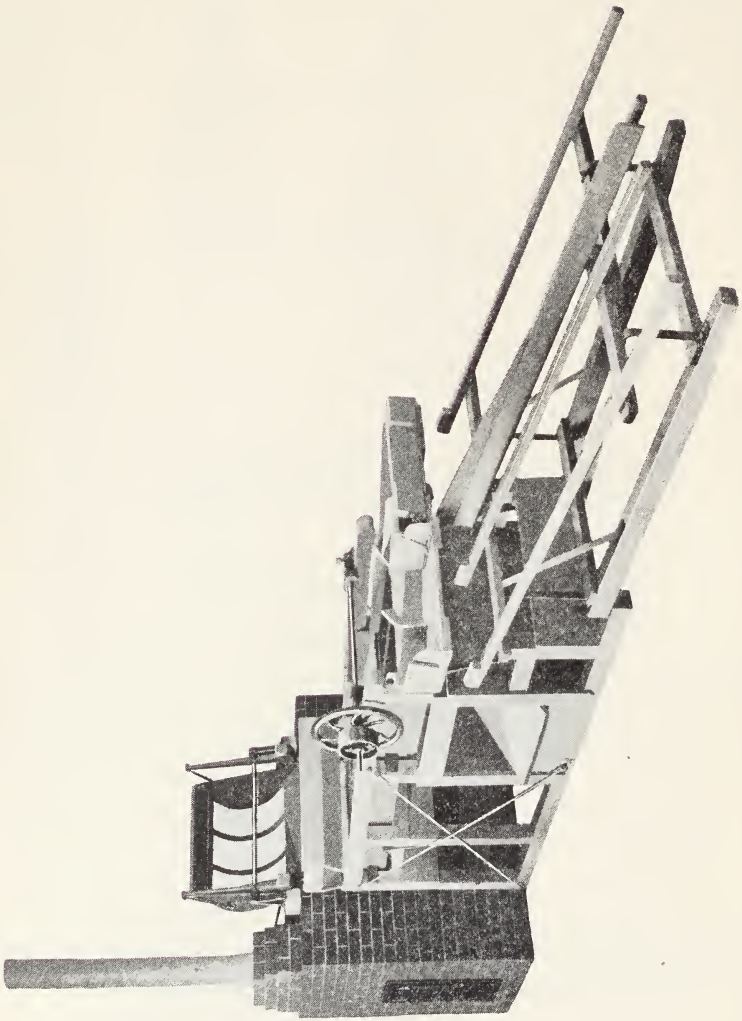


Fig. 5.—Hand-operated basket prune dipper with lye tank and furnace, connected to power-driven grader. Tray supports are shown in the foreground.
(Cut furnished by Anderson Barngrover Co.)

Sharp knives and means for sharpening them should be provided. A system of cards for the cutters and a punch for indicating the number of boxes cut makes a satisfactory record for payment of cutters. In this connection, it may be emphasized again that the boxes should be filled uniformly. A first-aid kit, including iodine or some other good disinfectant, bandages, and adhesive tape, should be readily available, and immediate cleaning and treatment should be given to cuts. A suitable water supply, soap, and sanitary toilets should be conveniently located, and cutters and yard workmen should be made to use these facilities.

Dippers.—Of the several types of dippers used, the simplest is shown in figure 5. This consists of an oblong basket with a rounded bottom of perforated sheet metal or wire screen, hinged to one edge of the lye tank. The latter is heated by a fire beneath it or, less commonly, by steam coils. The fruit is introduced from the boxes while the basket is in the lye. After the desired period of immersion the basket is raised by a hand-operated lever, discharging the fruit upon a shaker or chute leading to the trays.

Another type of basket dipper, called the "merry-go-round" (fig. 6), is used commonly in the Sacramento Valley for Thompson Seedless grapes. One or more baskets with counter-weighted levers are attached to a pivoted upright, allowing the baskets to be loaded, dipped into the lye bath, dipped into fresh water, and discharged upon trays in the course of one circle of movement around the upright.

For large-scale dipping, power-driven rotary or conveyor-type dippers are used. The rotary dipper (used only for prunes) is shown in figure 7. The perforated metal cylinder, mounted on a horizontal axis and containing a helical baffle to maintain positive discharge, rotates with the lower third submerged in the lye bath. The prunes are introduced at one side and discharged at the other. The speed of rotation, which is variable, governs the time of immersion.

The conveyor-type dipper has either baskets suspended from chains, or a metal-hinged belt with cross vanes, to carry the fruit forward. The fruit on the moving conveyor enters one end of an elongated lye tank and emerges at the other, the conveyor discharging the fruit on a shaker or chute leading to the trays.

The lye tanks are usually built of black iron, for the zinc on galvanized iron dissolves in the lye. Usually the tanks are heated directly by an oil flame below; gas, wood, and coal are also used. Where steam is available because of other needs, the lye solution may be heated by steam coils. In order to maintain the temperature of the solution at or near the boiling point a relatively large heating surface is necessary. The tanks usually

Fig. 6.—Merry-go-round basket dipper for grapes: *A*, basket being swung over dipping tank; *B*, loaded basket lowered into dipping tank.

hold 100 to 200 gallons or more; the larger tanks tend to be more uniform in temperature.

Power-driven dippers are often provided with trash screens over which the fruit passes on the way to the cylinder or conveyor. This screen helps to keep the lye bath clean, but usually cannot be provided for hand-operated basket dippers. Dippers of all types except the merry-go-round can be and should be provided with trash screens between lye tank and tray, where additional debris and the film of hot lye should be removed with sprays of cold water.

Pricker or needle boards may also be interposed between lye bath and tray, but they are difficult to keep clean and in good order, and appear to be of little value except for thin-skinned varieties of prunes such as the Imperial, in the dipping of which little or no lye is used.

Prune dippers in large dry-yards are often provided with grading screens also. This permits the large plump fruits to be trayed and handled separately from the small or shrunken prunes and promotes uniform drying.

Lye.—Commercial caustic soda or sodium hydroxide, about 95 per cent pure, in flakes, is the substance most commonly used for preparing dipping solution. It absorbs moisture quickly from the air; therefore to preserve the flake form it should be kept in tightly closed metal containers. Some brands of dipping material consist in part of sodium carbonate (washing soda), which is milder in its action than sodium hydroxide; some also contain sodium bicarbonate (cooking soda), which is still milder. With the latter two more must be used in order to get a similar effect. On the other hand, the risk of overdipping is reduced when sodium carbonate is mixed with the hydroxide. The milder substances are preferred by many for Thompson Seedless grapes and thin-skinned varieties of prunes. It is claimed by the manufacturers that mixtures of hydroxide and carbonate can be rinsed from the fruit more easily than the hydroxide alone.

Trays.—Most sun-drying trays are 2×3 feet, 3×6 feet, or 3×8 feet, but some $2\frac{1}{2} \times 7$ foot trays are used for pears. The 2×3 foot trays are intended chiefly for raisins, the 3×6 foot, for apricots and peaches, and the 3×8 foot for prunes; but all fruits are dried to some extent on all sizes of trays. The construction of the common types of trays is indicated in figure 8, and specifications, capacities, and approximate costs are given in table 3. Pine is the wood most commonly used, although spruce frames are said to give more strength; sometimes all redwood is used, but new redwood trays may stain light-colored fruits. In making the trays the rough side of the bottom shakes is turned toward the fruit to reduce sticking of fruit to the trays. Trays of heavy wrapping paper are used extensively for raisins but they are not much cheaper in the long run and are undesirable because more fruit is lost, more dirt gets on the fruit, and in the case of rain the fruit is very likely to be lost.

The regulations now enforced by governmental food authorities make it imperative that the trays be kept clean. Some juice from the fruit always sticks to the trays, resulting in the accumulation of dirt and mold that injure the appearance of the dried product. Immersion of

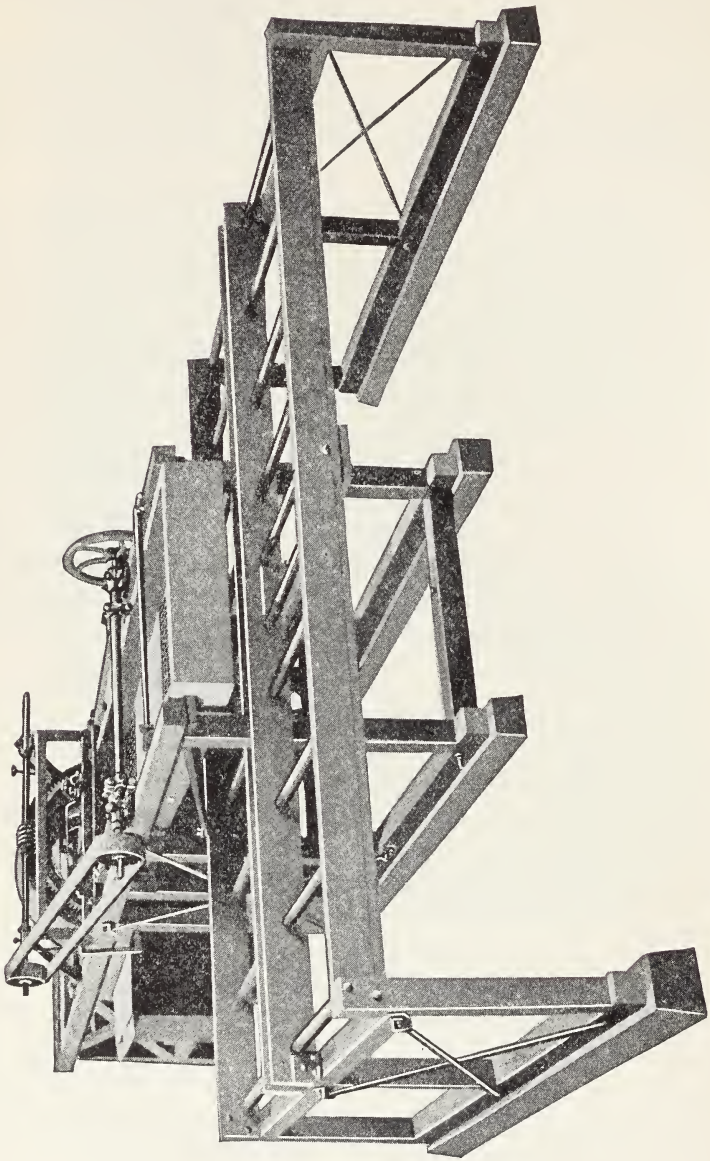


Fig. 7—Rotary-drum prune dipper and grader with roller tray conveyors.
(Cut furnished by Anderson Barngrover Co.)

the trays in water or soda solution, preferably hot, and vigorous use of a stiff bristle brush followed by rinsing, will secure clean trays. Strong lye solution applied by a power sprayer, followed by a thorough hosing with water has been successfully used. Prevention of molding is best accomplished by washing, sulfuring, and drying the trays before they are stored for the winter. In large dry-yards the provision of a washing device with sprays and power-driven rotary fiber brush, similar to those used at many grape dehydration plants, can be recommended.

TABLE 3

SPECIFICATIONS, CAPACITIES, AND APPROXIMATE COSTS OF STANDARD FIELD TRAYS

Standard specifications	2x3 foot trays	3x6 foot trays	3x8 foot trays
End cleats	2—⅞″x1¼″x3′	2—1⅜″x1¾″x34¼″	2—1⅜″x1⅞″x34¼″
Side cleats	2—⅜″x⅞″x3′	2—⅞″x1¾″x6′	2—⅞″x1⅞″x8′
Clinch cleats	.....	3—⅜″x1¼″x6′	3—⅜″x1¼″x8′
Bottom boards	5—5/16″x5¾″x2′ 1—5/16″x7¼″x2′	12—¼″x5¾″x3′	16—5/16″x5¾″x3′
Gross area in sqare feet	6	18	24
Average capacity in pounds:			
Apricots	10–12	30–36	40–48
Figs	13–17	40–50	53–67
Grapes	18–22	54–66	72–88
Peaches	15–20	45–60	60–80
Pears	18–24	54–72	72–96
Prunes	18–24	54–72	72–96
Approximate cost:			
In shook	$0.12	$0.46	$0.63
Made up	0.15	0.50	0.70

Sulfur Houses.—In design, cost, and efficiency there is great variation among the sulfur houses in use even though the sulfur house is essentially a simple structure. Regardless of details there are certain requirements that every sulfur house should meet: (1) it should be free from leaks in order to secure an effective concentration of the sulfur dioxide and prevent waste of sulfur; (2) it should be provided with a draft that can be controlled; and (3) it should not be too large to permit a reasonably uniform concentration of sulfur dioxide to be realized at all points in the house. For rapid, uniform sulfuring there must be dense white fumes in the house throughout the sulfuring period.

Sulfur houses are most commonly constructed of tongue and groove wood, but unless they are carefully built and kept in good repair and

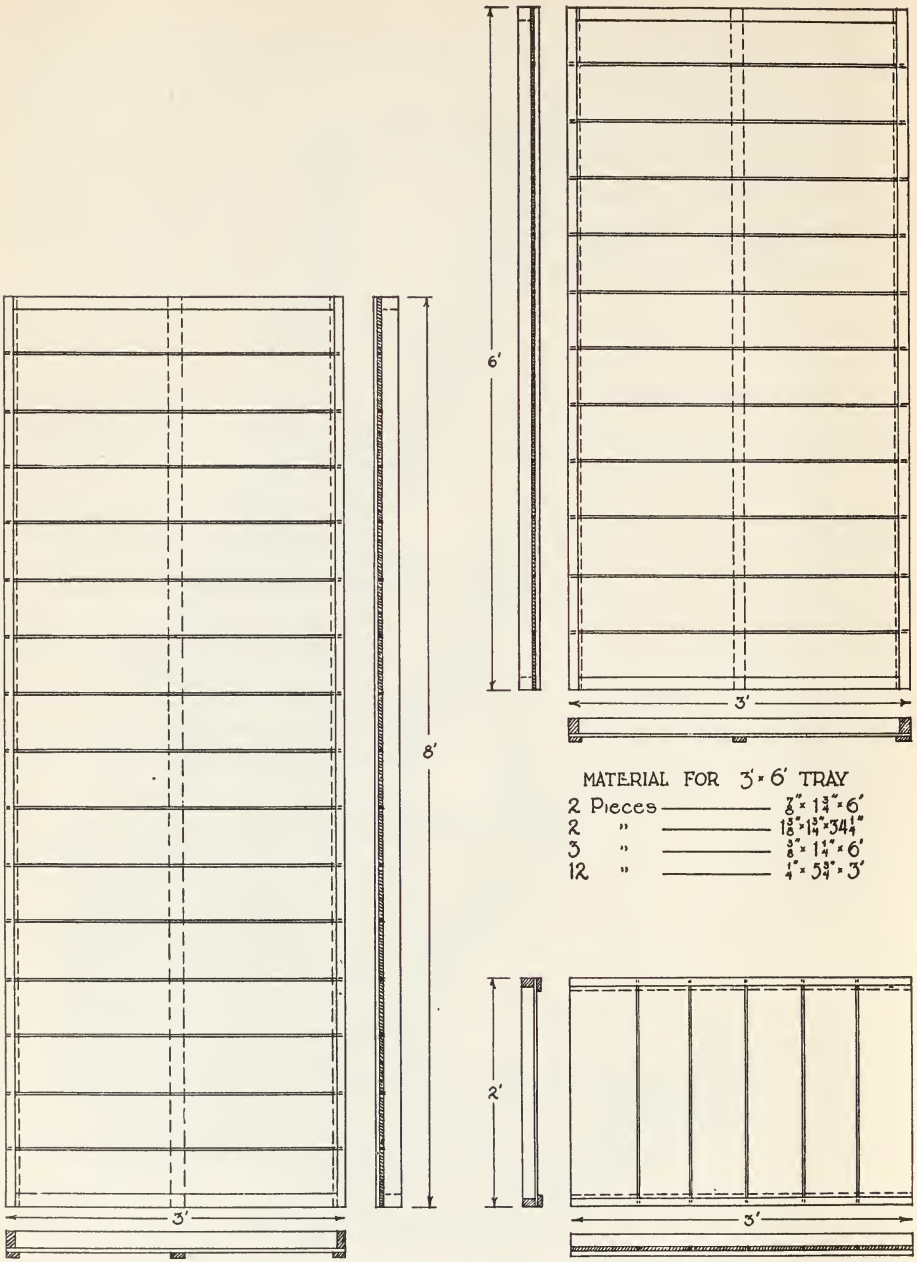


Fig. 8—Standard types of trays for sun-drying fruits.

the cracks kept well caulked, they may become very leaky and inefficient. Houses built of brick, concrete, or hollow tile are also satisfactory if the doors fit tightly, but because they are somewhat more costly to build, and are likely to be porous and cold they cannot be recommended in preference to those of wood. Sheet metal houses, even if covered with acid-proof paint, are not recommended because they corrode rapidly and are difficult to make tight.

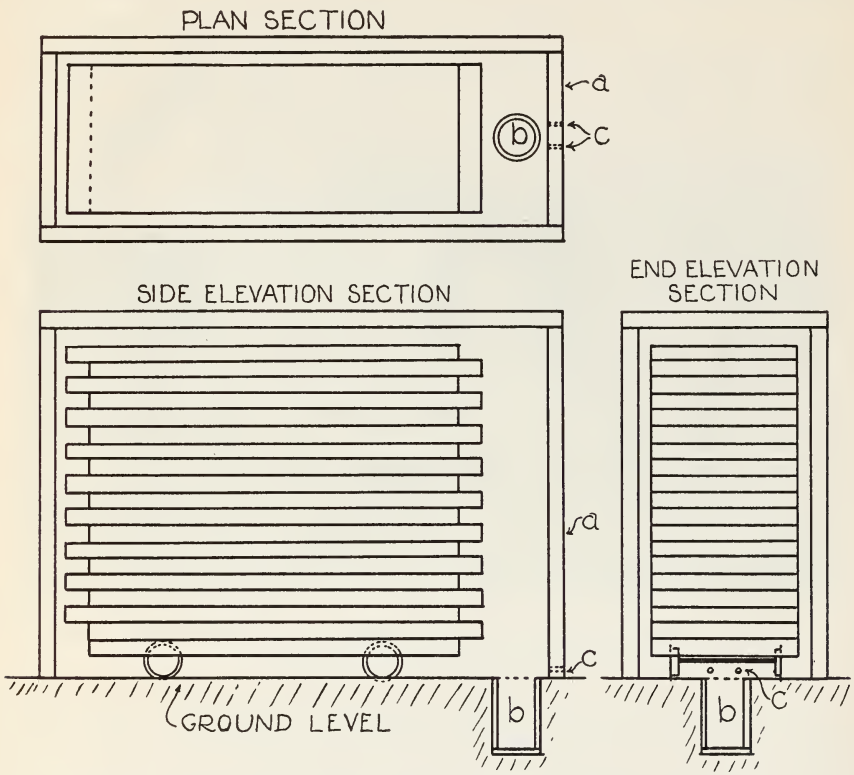


Fig. 9.—Diagram of a simple sulfur house: *a*, door; *b*, sulfur pit; *c*, draft holes.

Best results are usually obtained in houses that hold only one car; more than two cars in a house with a single sulfur pit will usually show a noticeable lack of uniformity of sulfuring. Ample end space should be provided in the house to allow at least 6 inches more than the diameter of the sulfur pit for circulation of the fumes at the pit end, and additional allowance should be made for the fact that the trays should be staggered as they are placed on the car for sulfuring. For a house holding one car of 3×8 foot trays the inside length should be about 10 feet;

height, 6½ feet; and width, 3½ feet. A design that has given good results in shown in figure 9. In places where the wind is very strong, whipping the fumes from the house, or where for some other reason the sulfur does not burn rapidly and completely, it may become necessary to install a power-driven fan and a system of pipes by which a gentle current of air is blown into each sulfur pit. This has been done very successfully at several large dry-yards. In such cases some sulfur can be saved by supplying air to the fan from the sulfur houses by a return system of pipes.

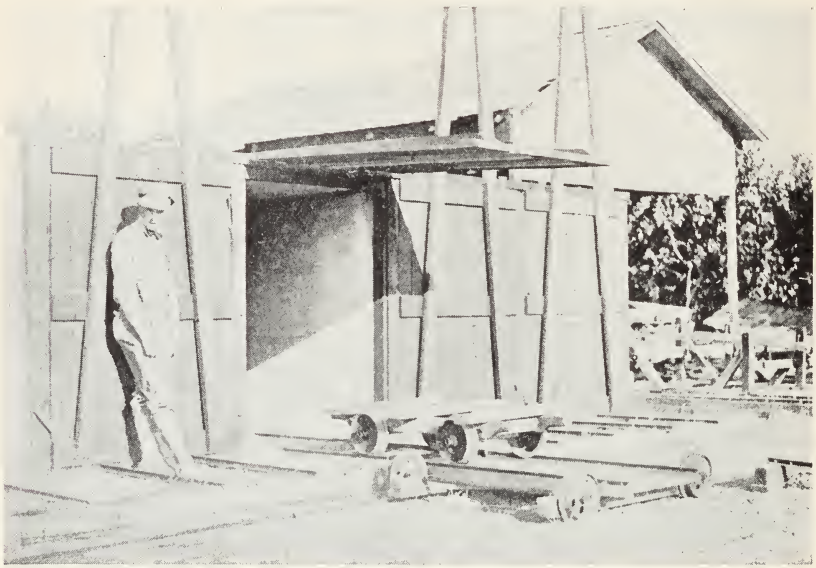


Fig. 10.—Typical sulfur houses with counterpoised doors hinged at top. Note transfer and tray cars.

In emergencies or when the expense of building first-class sulfur houses cannot be undertaken, portable houses or hoods such as that shown in figure 11 can be made to serve. If covered with roofing paper they are likely to be very short-lived, but various types of wallboard or sheet-wood are more durable and can be made fairly tight if they are coated inside and out and the cracks filled with heavy asphalt paint. Loose dirt shoveled against the bottom reduces the loss of fumes.

Whatever the material of which the sulfur house is constructed, it is a good plan to caulk cracks and apply thick asphalt paint each year. Too few dry-yard operators realize that a sulfur house cannot be depended upon for good work at all times unless *every* visible leak is stopped. Among the preparations on the market that have been found useful in filling large cracks are Hydroseal 1042 and other asphalt plastic ce-

ments, while for cracks through which little or no light may be seen, or for maintenance of good joints, an asphalt paint such as Gilacoat or Hydroseal 1094 is satisfactory.

Sulfur.—The main requirement of sulfur is that it shall burn readily; it should also be free from arsenic or oil and should leave no sooty residue. Most brands of sulfur on the market meet these requirements, although the relatively expensive flowers of sulfur is most commonly

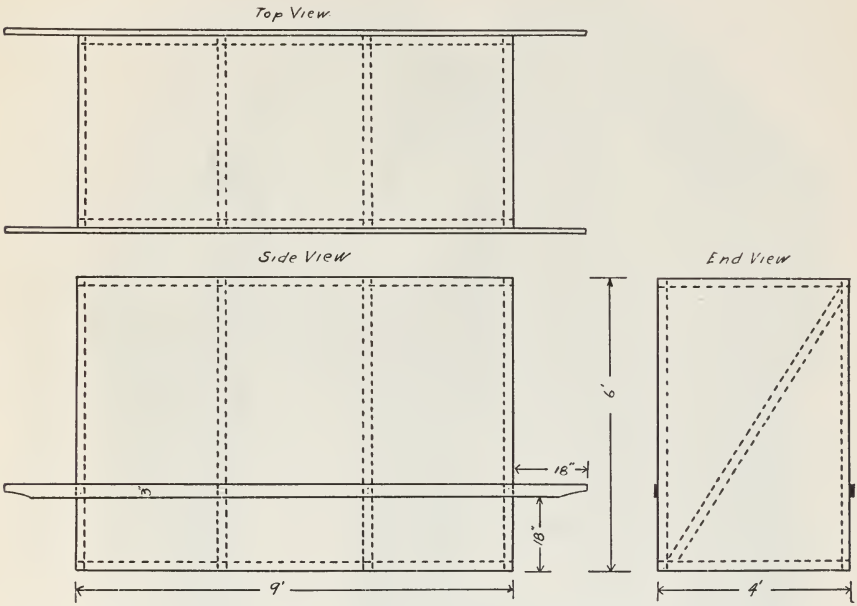


Fig. 11.—Balloon-hood sulfur box. The frame is constructed of 1 × 2 inch lumber, and is covered with 3-ply building paper.

used because as a rule it burns more readily, especially if the sulfur is burned in the pit itself. On the other hand, in some cases the cheaper ground or lump sulfur burns as well or better, for no reason that is apparent. Where this type of sulfur tends to burn incompletely, the difficulty can usually be overcome by burning it in several pans one above the other (fig. 12) and thus using a part of the heat of combustion to force combustion in the upper pans; but this occasionally leads to trouble by subliming some sulfur. Any residue left from incomplete combustion need not be thrown away, for it will burn if mixed with other sulfur and given the proper amount of draft. As one means of assuring rapid and complete combustion the sulfur and the pan or pit should be kept dry. Mixing 1 pound of sodium nitrate (Chile saltpeter) with 20 pounds of sulfur will permit burning under very difficult conditions.

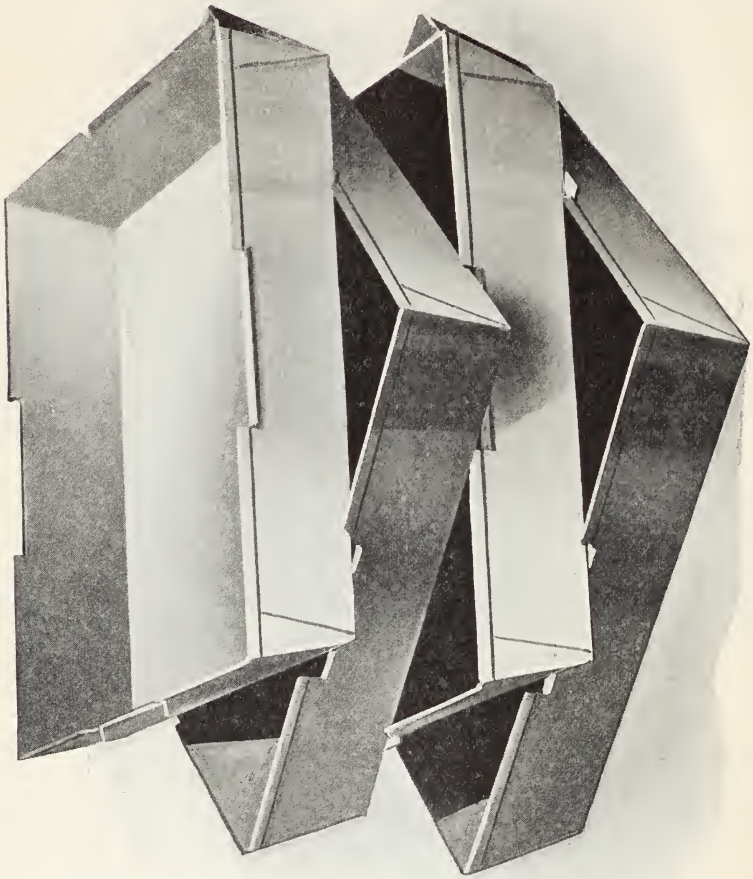


Fig. 12.—Multiple pans for burning lump sulfur. (Cut furnished by Texas Gulf Sulfur Company.)

Storage Boxes and Bins.—Provision must be made for at least temporary storage of all dried fruits before delivery to the packing house. The preferred method for raisins and figs is to scrape the fruit from the trays directly into sweat boxes. These are about 38½ × 26¾ inches and 7¾ inches deep, with 1¼-inch ends and ⅞-inch pine sides and bottom, strengthened by corner posts. Each holds about 125 to 150 pounds of fruit. Raisins are commonly stored in these boxes not only at the grower's shed but also at the packing-house until packed. Apricots, peaches, pears, and figs are often placed in sweat boxes by the grower, but are emptied out into bins at the packing-house. On the other hand, prunes are usually dumped by the grower in piles upon a clean wooden or concrete floor, and to equalize moisture content they are turned with shovels at intervals of a few days for about two weeks after the fruit is taken from the trays. While the cut fruits such as apricots and peaches are often dumped in piles, they are not generally turned. Pears, and often other fruits, are placed in lug boxes after drying. The use of burlap sacks cannot be recommended for cut fruits on account of the tendency of the fruit to accumulate dirt and to curl, so that they lose size when graded. The delivery of prunes to the packing-house in sacks is, however, nearly universal.

Only when a number of lots of fruit must be held in a small floor area by the grower is it necessary for him to construct bins with removable sides of planking, such as those used in packing-houses. This method of storage is naturally more economical of space and equipment than is storing in boxes, or even in sacks.

METHODS OF PREPARATION AND DRYING

It seems unnecessary in this circular to discuss in a general way many of the actual methods used in preparing and drying fruits, since they are described in some detail in the sections on the various fruits. Those who are particularly interested in the sulfuring process will find it dealt with more fully in another publication of this station.[5]

Apricots.—Apricots are dried with the skin attached and without washing unless they have been soiled by contact with the ground. The fruit is cut by hand. A sharp knife should be used and the cut made completely around the suture; care should be taken to avoid tearing the fruit when the halves are separated and the pit removed. Many cutters will tear soft fruit apart because it is easier or quicker, but this

[5] Nichols, P. F., and A. W. Christie. Drying cut fruits. California Agr. Exp. Sta. Bul. 485:1–46. 1930.

results in a product with rough edges and poor appearance. The pits should be collected in special cans or boxes to avoid soiling fruit, and should be dried in the sun without sulfuring, for use in the manufacture of by-products. The halves of fruit are laid on trays, close together and with the cups upward.

Apricots can be dried whole although the halved product is the only one for which there is a demand. If dried whole, the fruit should be dipped for about 10 seconds in 1½ per cent boiling lye solution before it is sulfured, to hasten the absorption of sulfur dioxide. If desired, the pits may be removed by squeezing in the hands after the fruit has dried about 2 days in the sun.

The trays on which the cut or whole fruit has been spread should be stacked on the trucks in staggered fashion so the ends of alternate trays overhang about 6 inches, allowing circulation of the sulfur fumes. The fruit should be sulfured as soon as practicable after being placed on the trays. Some growers sprinkle the fruit before sulfuring, especially if it has stood for some time, but this cannot be recommended because experiments have shown that it does not hasten the absorption of sulfur dioxide, and drippings from one dirty tray may soil the fruit on lower trays.

Most growers sulfur halved apricots for 2 to 4 hours; many leave them in the sulfur house overnight, but usually the sulfur does not burn all night. In a tight house that is operating efficiently, an exposure of 2 to 3 hours, and the use of 3 to 4 pounds of sulfur per fresh ton of fruit are sufficient for halves; whole fruit requires about twice as long for a similar absorption. To secure and retain the best commercial color, apricots when dry should contain at least 1,500 parts per million of sulfur dioxide, but on account of governmental regulations in certain important markets, the amount should not exceed about 2,000 parts per million. The only reliable way to determine whether sulfuring is being properly done is by chemical analysis, facilities for which are usually maintained by dried-fruit packers. A very rough test, not by any means reliable, is that when the fruit is removed from the sulfur house the flesh of average pieces should appear cooked about two-thirds through.

As soon as possible after sulfuring the fruit should be spread in the sun. Allowing it to stand in the sulfur house or elsewhere permits the accumulation of juice in the cups; if there is much juice it is likely to be spilled, and spilling of juice not only soils the trays but also decreases the yield.

Some growers leave the fruit in the sun until it is sufficiently dry, especially when they are short of trays. Somewhat better color and size can be obtained by stagger-stacking the trays (fig. 13) with the ends

toward the prevailing winds after the fruit is about half dry. The time of exposure to the sun that is necessary depends upon the weather, a minimum being 3 days for half-drying preparatory to stacking, and 5 days for drying completely in the sun. The fruit should attain a flexible "kid-glove" texture in the stack.

Fig. 13.—Scraping dried apricots into lug boxes. Note staggering of trays in stacks.

The transfer of the fruit from trays to boxes (fig. 13) affords the best opportunity for sorting out pieces that are discolored, dirty, slabbed, or otherwise defective. How well it will pay the grower to remove the lower classifications of fruit completely will depend on the grower's contract with the buyer or packing house.

According to a survey made several years ago,[6] approximately 28 man-hours per fresh ton were required on the average for picking and all other labor except cutting, and 7 pounds of sulfur was used in drying one fresh ton of apricots.

Peaches.—Only freestone varieties are sun-dried. Like apricots, peaches are dried with the skin attached, but peaches are always pitted. The pits are collected and dried, although at present they are used only for fuel and are less valuable than apricot pits.

The sulfuring and drying of peaches differs from that of apricots chiefly in that the sulfuring period should be about 1 hour longer and the drying period is at least 2 days longer.

[6] Christie, A. W., and L. C. Barnard. The principles and practice of sun-drying fruit. California Agr. Exp. Sta. Bul. 388:1–60. 1925. (Out of print.)

In a survey of peach dry-yards an average of 8½ pounds of sulfur and 17.3 man-hours for picking and all other labor except cutting was found[7] to be employed in drying 1 fresh ton of peaches.

Pears—The preparation of pears for drying includes two steps not usually included with other fruits. As the pears are still green and hard when picked they must be brought to a suitable stage of ripeness. Pears

Fig. 14.—Drying pears in Lake County. Note wooden horses for tilting trays toward south, and open sheds for stack drying.

for drying, however, are allowed to remain on the tree for a longer time than for fresh shipment in order to attain greater size and sugar content. Ripening is usually accomplished by allowing the fruit to stand in lug boxes at a moderate temperature, and sorting out the fruit for cutting as it ripens. Sorting may be eliminated and ripening hastened by treating the pears with ethylene gas in a tight room or under a tarpaulin. The most satisfactory dosage of the gas in a tight room is about 2/10 cubic foot at atmospheric pressure for each 1,000 cubic feet of space, applied twice daily, with thorough ventilation between applications of the gas. Under a tarpaulin or canvas 1 cubic foot of gas should be used per 1,000 cubic feet of space, and special ventilation is unnecessary. For best results the temperature of storage should be between 70° and 80° Fahrenheit. The advantage of the ethylene treatment is that all

[7] See footnote 6, page 25.

the pears ripen practically at once, eliminating the need and cost of sorting. However, it is of doubtful economy for a small-scale operator.

Pears, if they have been sprayed, as is usual in California, also require special treatment to remove arsenical and lead spray residues. One of the most successful methods of removing the residue is to dip the fruit in ⅓ to ½ per cent hydrochloric acid solution; sometimes as much as 3 minutes of immersion is necessary where the fruit is merely dipped, but in power spraying machines 30 seconds may be sufficient. Sometimes rubbing the fruit with toweling will remove enough of the residue to meet the government tolerance.[8]

When the pears are cut for drying the calyx should be removed. In cutting, care should be taken to separate the fruit into two equal halves unless it is of abnormal shape. Besides cutting out the calyx the cutters should pull or cut out the stem. It is not customary to remove the core. Of course worm holes should be cut out and badly damaged fruit should be discarded. The fruit is then spread on trays, cut surface up.

In Lake and Mendocino counties the trayed pears are usually sprinkled with cold water or dilute brine, after which they are sulfured for from 24 to 72 hours, replenishing the sulfur at about 8-hour intervals. Although Lake and Mendocino pears are reputed to be of the highest quality produced, this is due to the fact that better grades of fresh fruit are used rather than to the sprinkling and long sulfuring period. In other sections the pears dried are generally culls from fresh shipments or culls from canners' supplies, and they are sulfured less than 24 hours. Six hours may be regarded as a minimum for satisfactory keeping quality, and longer is often required to give the translucency that is desired. As with other fruits, the riper the fruit the shorter the sulfuring period needed.

In order to secure the best color, pears should be exposed to the direct sunlight for only ½ to 2 days. Tilting the trays toward the south is common in Lake County (fig. 14). After exposure the trays are stagger-stacked and the top tray covered. The trays are often separated by blocks or sticks to facilitate circulation of air. During the 2 to 4 weeks' period usually required to complete drying in the shade the trays are restacked several times and culls and underdry or overdry pieces are sorted out for separate handling. The finished product should be flat, flexible but not mushy, with little curling or browning of the cut edges.

[8] Diehl, H. C., J. M. Lutz, and A. L. Ryall. Removing spray residue from apples and pears. U. S. Dept. Agr. Farmers' Bul. 1687:1–31. 1931. (For sale by the Superintendent of Documents, Government Printing Office, Washington, D. C. for 5 cents in coin.)

Twelve pounds of sulfur and 26.5 man-hours exclusive of cutting were found by Christie and Barnard[9] to be used in drying a fresh ton of fruit.

Figs.—Since figs are already partly dried when brought in from the orchard, the drying process is relatively simple. In fact some growers dry black Mission figs by collecting them from the ground directly into burlap sacks which, when about half full, are tied and flattened out on the ground under the tree. The sacks are turned every 2 or 3 days until sufficiently dry. A difficulty with this method is that the fruit is likely to be soiled by dirt and lint.

Most figs are gathered from the ground at frequent intervals and brought to dry-yards, where wet figs or those that are nearly or quite dry enough are separated. *Calimyrna* and *Mission* figs are trayed and exposed to the sun for a few days, then stacked until dry enough for boxing. *Adriatic* figs are usually dipped and sulfured before being spread in the dry-yard. The dipping cleans the fruit and increases the absorption of sulfurous acid. For the dipping solution many growers use 5 to 20 pounds of salt in 100 gallons of water, to which some add also 5 to 20 pounds of lime, but experiments have shown fresh water to give just as good results. The fruit after dipping is sulfured for about 4 hours, spread in the sun for 2 to 4 days, and finished in the stack.

During the last 4 or 5 years appreciable tonnages of cannery-cull fresh Kadota figs have been dried. These are simply spread on trays, sulfured 2 to 4 hours, and spread in the sun until nearly or quite dry enough for boxing. So far the outlet for such figs has been almost wholly limited to fig-paste manufacturers.

In 1927 the federal Food, Drug, and Insecticide Administration, partly to protect California growers against competition from imperfect imported figs, reduced the official tolerance for bad figs from 35 to 10 per cent. While this has reduced the importation of figs, most California growers and packers have difficulty in meeting the tolerance. Packers accept figs from growers without penalty only if the proportion of insect-infested, moldy, sour, birdpecked, dirty, or worthless fruits does not exceed 10 per cent; and on account of the difficulty and expense of removing defective fruit at the packing-house, they usually reject any lots that are more than 30 per cent defective.

As several types of spoilage cannot be detected until the fig is opened, it is obvious that the grower should cull out *all* fruit that can be seen to be bad when it is transferred from tray to boxes.

On account of the increased danger of infection during caprification, the Calimyrna is somewhat more difficult to keep clean than the Adri-

[9] See footnote 6, page 25.

atic, while the Mission is somewhat less difficult than the Adriatic. Light shaking of the trees and frequent harvesting of fruit from the ground help to forestall spoiling of the figs, and careful cleaning up and disinfection of caprifigs has been found to be of distinct benefit in the case of Calimyrnas, at least so far as the mold disease known as endosepsis is concerned. The cannery-cull Kadota, which is picked fresh before infection and infestation become serious, is practically free from these troubles.

Fig. 15.—Effect of proper lye dipping on the skins of prunes.

When properly dried the interior of the fig should be of the consistency of stiff jelly, free from juice, and the skin should be flexible.

A typical crop of Adriatic figs was found[10] to require 32.7 man-hours of labor apart from picking, 19 pounds of salt, 13 pounds of sulfur, and, for dipping, 14.5 kilowatt-hours of current per dry ton.

Prunes.—Practically all prunes are harvested from the ground. Prunes of the Burton variety have in the last few years been picked from the trees by hand for drying and the results are said to be sufficiently better to justify the additional cost, but even with this variety the practice is not general. In the coast districts practically all fruits drop to the ground without the necessity of shaking the trees, but in the

[10] See footnote 6, page 25.

interior valleys most of the fruit must be shaken or knocked from the trees. An investigation, not yet completed, seems to indicate that in the valley districts, at least, the yield and quality are not improved and may be impaired by leaving the fruit on the tree after the middle of the usual harvesting season is reached. A darkening of the flesh frequently appears by midseason or earlier and becomes much more pronounced as the fruit remains on the tree. On the other hand, harvesting all the fruit from the tree before midseason tends to reduce yield and probably

Fig. 16—Turning prunes to facilitate drying.

quality. In the valley districts, therefore, only moderate shaking of the trees in early season, with a clean-up beginning at midseason, seems likely to give the best results. Three or four harvestings should be made.

As soon as possible after harvesting, the prunes should be dipped and spread on trays. A fresh tank of dipping solution should be made each day, and its strength maintained by frequent small additions of lye during use, to compensate for mechanical loss and neutralization by fruit acid. For French prunes the solution should contain about 1 pound of lye (caustic soda) to 20 gallons of water, and should be maintained at about 200° Fahrenheit, close to the boiling point. Under these conditions immersion for 5 to 15 seconds will be sufficient, and it is desirable that the temperature and the strength of lye be great enough to do the necessary checking in the shorter exposure. The skin should be definitely checked as shown in figure 15, but large cracks or peeling of any fruits should be avoided. Tough-skinned varieties such as the Robe de Sergeant require a more severe dip, while a weaker, cooler, or shorter dip should be used for the Imperial, which some growers dip in plain hot water. Rinsing the fruit after the lye dip by immersion in running water or better by sprays is desirable, though not always done.

If the prunes are not fairly uniform in size and in stage of dryness it is advisable to use a size grader as a part of the dipping equipment, and spread the large and the small prunes on separate trays. A hand-operated or power-driven shaking device is of great assistance in spreading the fruit, which should be only one layer deep on the trays.

The average requirement for dipping was found[11] to be 1.3 pounds of lye, 2.5 kilowatt-hours of current, 2 gallons of fuel oil, and 1.95 man-hours of labor per fresh ton. The labor requirement for drying was 8.3 man-hours per fresh ton.

In the dry-yard the prunes are left exposed to the sun until they are at least three-quarters dried, when the trays are stacked. This usually requires a week or more, and during this time large prunes should be turned or raked to secure even drying (fig. 16). Imperial and Sugar prunes are usually stirred by having two men shake the trays back and forth. In case of wet or foggy weather the trays must be stacked and covered and then spread again as soon as the weather will permit drying. In long-continued bad weather, prunes that are less than three-quarters dry may have to be finished in a dehydrater in order to save them. Because prunes are dried late in the season, the weather may increase the cost of handling or the danger of loss to such an extent that many growers use dehydration altogether.[12]

When the fruit is sufficiently dry the flesh should be firm and the pit should not slip when a prune is squeezed between the thumb and forefinger. On emptying the trays, mashed prunes, or slabs, and bloaters, frogs, and chocolates,[13] which result from improper maturity, insufficient dipping, or fermentation, should be culled out (fig. 17) since at this point they can be more easily seen and removed than at any later time.

Grapes.—Most raisins produced in California are dried by the "natural" method, in the vineyard. Before picking begins and before the trays are distributed, many growers, using a plow or drag, throw up a ridge of soil on the south side of every other east-and-west row of the vines. The pickers spread the fruit one bunch deep on the trays as it is cut, resting the north end of the tray on the ridge, tilting the tray to the south. The ends of the trays may be reversed after about four days. By

[11] See footnote 6, page 25.

[12] For information on the building and operation of prune dehydraters, see: Christie, A. W. The dehydration of prunes. California Agr. Exp. Sta. Bul. 404:1–32. Revised 1929 by P. F. Nichols.

[13] "Chocolates" are prunes that dry to a chocolate-brown color. "Bloaters" and "frogs" are puffy prunes containing large air pockets usually resulting from fermentation.

covering with an empty tray the fruit is turned upside down after the top layer of berries has browned and shriveled, usually a week or 10 days after spreading. When all traces of green have disappeared and the grapes are about two-thirds dry, the trays are stacked. When paper trays are used the grapes are not turned, and when dry enough for stacking the edges are turned in and the trays rolled. The trays having been stacked or rolled, the raisins remain in the vineyard for curing until they are ready for boxing. Naturally, grapes on paper trays are

Fig. 17.—Sorting dried prunes.

very susceptible to damage in case of rain, when they may become badly sanded as well as moldy. When the raisins are so dry that juice cannot be squeezed out between the fingers, they may be placed in sweat boxes. The sweat boxes should remain either in the vineyard or in a stack for several weeks before delivery to the packing-house, in order to permit the final curing or equalization of moisture.

Currants are also dried without any preliminary treatment and when the weather is hot, are best dried on stacked trays without any direct exposure to the sun.

While all currants, nearly all Muscats, and most of the Thompson Seedless (Sultanina) and Sultana varieties are dried in the natural condition, about 5 to 15 per cent of the Sultanina and Sultana raisins are dipped before drying. Aside from the dehydrated Thompson Seedless that are dipped and sulfured to produce the so-called Golden Bleached raisin, the seedless raisins dried after dipping are of three types: soda-dipped, oil-dipped, and sulfur-bleached.

Soda-dipped Thompson Seedless are dipped much as are prunes. The dip usually contains 1 pound of caustic soda to 20 gallons of water, although some growers prefer the weaker sal soda (sodium carbonate)

or the still weaker cooking soda (sodium bicarbonate) in order to avoid the danger of overdipping. A very small quantity of olive oil may be added to the dip. When lye (caustic soda) is used and the solution kept at or near the boiling point, immersion for 5 seconds or less will produce the numerous small cracks desired. For uniform checking the grapes must be of uniform maturity, since underripe fruit checks much more readily than that fully ripe. After rinsing in fresh water the grapes are spread on trays and exposed to the sun, turned after 3 or 4 days and stacked in about a week. The finished raisins are of a distinctly reddish brown color, somewhat translucent.

Oil-dipped raisins are made in two somewhat different ways. In one the grapes are dipped for 30 seconds to 3 minutes in an *unheated* solution containing about 30 pounds of cooking soda (sodium bicarbonate) and 1 pound of lye in 100 gallons of water, on which a film of olive oil is floated. About 5 pounds of sodium bicarbonate and 1 quart of olive oil are consumed in dipping 1 ton of grapes. In the other method a *hot* sal soda or cooking soda solution with a film of olive oil on the surface is used for dipping. In both cases the grapes acquire a perceptible film of oil as they leave the dip. Drying is carried out as for soda-dipped raisins. The finished product is usually darker in color than the soda-dipped and has a slightly oily surface.

Sulfur-bleached raisins are first dipped in the same manner as soda-dipped raisins, then sulfured for 2 to 4 hours. They are then spread in the sun, turned after ½ to 1 day, the time required depending on the weather, and stacked after twice that length of time. Drying is completed in the stacked trays, except for the final curing or moisture equalization in boxes. The finished product should be of a yellowish-white waxy color. Over-exposure to the sun will produce a too-brown or amber color.

A type of raisin produced extensively in Australia but so far only in an experimental way in California may be worth describing here for the benefit of those who might wish to consider producing it. It represents an attempt to produce a raisin of the Smyrna type, which enjoys a trade preference in the British market. Only the Sultanina variety is used, and the grapes should be well and uniformly colored, with juice testing 24° Balling or more. An unheated dip is used, containing 25 pounds of commercial potassium carbonate to each 50 gallons of water. To this is added 1½ pints of olive oil previously emulsified in a diluted portion of the solution, care being taken to discard any floating oil not emulsified by the shaking or stirring. The grapes are immersed in this solution until the bloom is removed, usually requiring about 4 minutes

when the amount of olive oil is correct. More solution and especially more emulsified olive oil must be added from time to time to replace that lost with the grapes; it is not necessary to make up a fresh solution until the old becomes sirupy from the juice of the grapes. After dipping, the grapes are drained and spread to dry either on wooden trays or on wire-screen racks supported 12 to 18 inches above one another in a roofed shed without sides. During drying the grapes are sprayed in good weather every 2 or 3 days with the dipping solution. When there is heavy dew, fog, or rain the grapes are sprayed again. Care is taken to avoid touching the grapes during drying, and to avoid spraying the grapes heavily enough to cause them to drip. When the grapes are dried on wooden trays the above are the only treatments required, and the product closely resembles the California soda-dipped raisin though slightly lighter colored. When dried on the wire racks in the shade a finished product of much lighter and more uniform color is obtainable, but two additional steps are involved. When the raisins are sufficiently dry to box and have been lifted from or shaken through the wire racks, they are distinctly greenish in color. To remove any incrustation of potassium carbonate that remains from the first dipping and the sprayings the fruit is again dipped or rinsed, this time for a few seconds in a solution containing 2½ pounds of potassium carbonate and 1½ pints of olive oil, thoroughly emulsified, in 50 gallons. When drained the fruit is spread on trays or tarpaulins (in Australia burlap is used) and exposed until the green color disappears and is replaced by a light amber. This final exposure usually requires from 1 to 3 days, depending on the weather, and during this period the raisins should be raked or stirred frequently to get a uniform color. The amount of handling necessary is obviously a disadvantage, but when successfully applied a product of exceptional color and uniformity results from this method.

Cherries.—Cherries are dried on a small commercial scale by simply spreading the fruit on trays and exposing to the sun until thoroughly dry. Usually only fruit not suitable for fresh shipment or canning is dried.

Rain Damage.—During the season for drying apricots, peaches, pears, and figs there is no danger of damage by rain, but the prune and raisin drying season is later, and more or less difficulty from rain and foggy weather is to be expected in the sun-drying of these two fruits.

In the event of rain the trays should be stacked, before the rain if possible, and the stacks covered with empty trays. The difficulty of handling raisins on paper trays under these circumstances is obvious, and in case of a heavy rain, even of short duration, serious damage to the fruit is

likely to occur. The trays should be spread as soon as possible after the weather clears. The processes of stacking and spreading must be repeated as often as the weather changes, sometimes daily. Stirring the fruit on the trays is very desirable.

When the weather is very bad and the trays and fruit become very wet, such practices as elevating the trays by propping one against another, transferring to dry trays, or dipping in hot water, lye, or salt solutions will not avail. In such a situation only two treatments are likely to be of much use: sulfuring, or finishing the drying in a dehydrater.

Many growers drying prunes and natural raisins are not equipped with sulfur houses. In this case the balloon-hood type of sulfur box shown in figure 11 (page 21) can be constructed quickly and cheaply, and may be of great value. Sulfuring the fruit from 1 to 3 hours will effectively prevent molding or fermentation. Unless the fruit is nearly dry, sulfuring will cause prunes to be distinctly red in color, but where dehydrating facilities are inadequate or unavailable, this is preferable to complete loss.

There are now in the state about 500 dehydraters, in which about 20 per cent of the prune crop and 5 to 10 per cent of the raisin crop is normally dried. Dehydration is the ideal way out of the rain-damage difficulty, and should be applied as promptly and fully as possible. For natural raisins the temperature should not exceed 140 to 150° Fahrenheit, while for prunes 165° is safe if not exceeded.

HANDLING FRUIT AFTER DRYING

There are a number of considerations that are more or less common to all dried fruits, especially after drying. Most dried fruits are not offered for consumption as they come from the dry-yard, but are first stored for some time and subjected to some cleaning or other treatment that amounts to a manufacturing process. Ordinarily this is not done on the farm but in a packing-house, with which this circular has nothing to do directly. The success of the packing process and of the whole dried-fruit industry is, however, dependent on the grower's care and skill all the way from the growing of the fruit until it actually reaches the packing-house. Failure to dry his fruit sufficiently, or to store it properly as long as it remains in his possession, may result in partial or complete loss of the product.

Proper Degree of Dryness.—Overdrying reduces the weight of dried product to no good purpose, but thorough drying is essential to good

keeping quality. Raisins should contain from about 13 to not over 18 per cent moisture, while other fruits should be within the range of 15 to 20 per cent moisture. If these upper limits are not exceeded the fruits will keep well during prolonged storage, and the necessary addition of moisture during processing at the packing house may be made without much risk of spoilage. As a general thing growers cannot undertake the actual determination of moisture content in their product and must depend on certain rather crude tests at which skill is acquired only after long experience. For example, it should not be possible to squeeze out with the fingers any sirup from individual pieces of fruit, the skin should not separate from the flesh by rubbing, and the pits of prunes should not "slip." Pieces that fail to pass these tests should be sorted out when the trays are emptied. On the other hand, the fruit should not be so dry as to rattle and sound like pebbles when pushed about or shaken on the trays. When a handful is squeezed the fruit should feel pliable, yet on release of the pressure the pieces should not stick together to form a ball but should fall apart immediately and return to their original shape.

Curing or Sweating.—When boxed or binned the individual pieces of fruit always vary in moisture content. During the first 1 to 3 weeks in the box or bin some moisture is transferred from the wet to the dry pieces either by direct contact or by evaporation into the air spaces and absorption therefrom. It is from the latter type of transmission that the process gets its common name of "sweating." Until this equalization of moisture is virtually complete it is difficult to judge accurately whether the moisture content is satisfactory in lots that are close to the upper limit. Sweat boxes are ideal for this curing process except perhaps for prunes, which are usually dumped on a clean concrete floor and turned with shovels every few days.

Storage on the Farm.—For the safety of the fruit it is best that it be delivered to a packing-house not less than two weeks nor more than a month after it is removed from the trays. While packing-house facilities and processes are not to be described in this circular, it may be said that as a rule better provision for and supervision of storage are available there than on the farm. But whether the storage on the farm is short or long, the conditions should be the best that can be provided. The storage space should be cool, dry, and well lighted and ventilated. Care should be taken to exclude rodents and poultry. Extreme care should be taken to prevent insect infestation, which may ruin the fruit on the farm or, later, at the packing-house. To this end any dried fruit from the previous crop should first be removed from the building and sweepings burned, for such material is always infested and the infestation will quickly

spread to the new fruit. The building, especially the walls and floors, should be thoroughly cleaned and if possible either gone over with a steam hose or fumigated. In order for fumigation to be effective the building must be made tight by closing all large openings and plugging all cracks. Fumigation of a bin or stack of boxes may be carried out with fair effectiveness by close covering with a tarpaulin in cases where the building as a whole cannot be made tight. Probably the most satisfactory fumigant from all points of view at the present time is ethylene oxide, a gas sold compressed in cylinders. For each 1,000 cubic feet of space 2 pounds should be used when the enclosure is very tight and twice that much or more when a tarpaulin is used or the enclosure is only fairly tight. The temperature should be at least 75° Fahrenheit and the exposure should be for 8 to 24 hours. Chloropicrin, a war tear gas, used at the rate of at least 2 pounds per 1,000 cubic feet of space, is also effective but can be used satisfactorily only where all persons and animals can be kept away during the fumigation. Compressed sulfur dioxide gas in cylinders has also been found effective when used at the rate of 7 pounds per 1,000 cubic feet of space, but sufficiently high concentrations of sulfur dioxide cannot be obtained by burning sulfur in a sulfur house with natural draft. Only cut fruits should be fumigated with sulfur dioxide.

Storage boxes should be well cleaned before the fruit is introduced. Unless they are to be fumigated with the fruit as soon as they are filled, they should first be fumigated in the empty storage space, or subjected to live steam inside and out, or immersed for a few seconds in a lye-dip tank filled with boiling water to which it is well to add 1 to 5 pounds of trisodium phosphate per 100 gallons.

Fly sprays with strong odors of kerosene or carbolic acid should never be used around fruit, whether fresh or dry. While many of these are effective in killing or repelling insects, the odor is very penetrating and persists even after cooking; hence their use is likely to make the fruit unsalable.

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